PATENT APPLICATION

INSULATED CONCRETE FORM AND WELDED WIRE FORM TIE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of the filing of U.S. Provisional Patent Application Serial No. 60/408,859, entitled "Insulated Concrete Form and Welded Wire Form Tie", filed on September 5, 2002, and the specification thereof is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention (Technical Field):

The present invention relates to a horizontally reversible insulating concrete form with opposing panels connected by wire ties, preferably welded wire ties with a metal sheet attachment stud, used to make concrete structures.

Description of Related Art:

Traditional concrete walls in building construction are generally made by setting up two parallel form walls and pouring concrete into the space between the forms. After the concrete hardens, the builder then removes the forms, leaving the cured concrete wall.

This common prior art technique has significant drawbacks. The resulting wall is not insulated, and significant labor is required to remove the forms after the concrete cures or hardens.

Techniques have developed for forming modular concrete walls that use a foam insulating form material, generally referred to as "insulating concrete forms" or by the acronym "ICF". Using modular forms, which are available in different sizes, walls are set up. Most insulating concrete forms are composed of two parallel panels, forming an exterior and interior wall panel, with ties, bridges or other connecting components holding the two panels in place relative to each other while concrete is poured into the cavity between the panels. The insulating form panels remain in place after the concrete cures. Thus no labor is required to either remove forms or add insulation, resulting in substantial efficiency. In most cases, the insulation of the form provides adequate insulation for the building, so that no additional insulation is required.

Insulating concrete forms are manufactured from a polymeric material, often polyurethane or polystyrene, which is expanded and formed within a mold to yield a rigid, low-density foamed plastic form having vertical and/or horizontal cavities to be filled with wet concrete. U.S. Patent No. 3,552,076, entitled *Concrete Form* to Gregori, and U.S. Patent No. 3,788,020, entitled *Foamed Plastic Concrete Form With Fire Resistant Tension Member,* also to Gregori, are two early patents that both teach methods whereby polystyrene foam is molded to yield a concrete form.

The construction industry has incorporated several means of attaching finishing materials to the outer sides of these molded construction forms after the concrete within the cavities has set. One such method has been to glue the paneling, sheetrock, or other suitable finishing materials to the outer surfaces of the completed form. Additionally, outer finishing materials may be rigidly attached using a penetrating device through the outer molded form to the cured concrete or other building material inside the form. Another method to attach finishing materials is to glue or nail furring strips on the outer surfaces of the forms. Gluing the furring strips to the foam forms require construction adhesive, and nailing the furring strips or the finishing materials to the outer sides of the forms require that special concrete nails be used. The application of these concrete nails, moreover, must be accomplished at a critical time during the curing of the concrete. Then, the finishing materials are nailed or screwed onto the furring strips.

Another approach to concrete forms is disclosed in U.S. Patent No. 4,223,501, entitled *Concrete Form*, to DeLozier. This patent teaches a method whereby a one piece transverse connecting member is embedded in the polystyrene concrete form taught in the Gregori patent. The connecting member has attachment flanges extending at right angles which extend near the outer surfaces of the form.

U.S. Patent No. 4,879,855 entitled *Attachment and Reinforcement Member for Molded Construction Forms*, to Berrenberg, discloses an attachment and reinforcement tie for molded construction forms with a central portion of expanded steel in which the ends are bent to accommodate covering strips of solid galvanized steel. The tie is embedded in a molded construction form during the form's manufacture. The strips of the solid galvanized steel extend to the outer surfaces of the form and provide attachment surfaces while the central portion of expanded steel web reinforces the form and connects the two panels.

It is known to have a groove on one end of both panels in an ICF, with a corresponding tongue on the other end of the panels, such that two forms may be joined together in a horizontal plane by means of a tongue and groove attachment. Among other patents, U.S. Patent Nos. 3,552,076, 3,788,020, 4,223,501, 4,698,947, 4,879,855, 5,459,871, 5,465,542, and 5,596,855 disclose forms of this type. Other patents disclose a shiplap joint on the ends of both panels in an ICF, as disclosed in U.S. Patent Nos. 4,516,372 and 5,568,710. However, all such forms can only be interconnected in a horizontal dimension in a specific direction, and the forms are not reversible.

While many forms utilize a plastic tie, there are a few forms which utilize a metal tie, such as U.S. Patent Nos. 4,879,855 and 5,568,710, which employ an expanded metal tie, U.S. Patent Nos. 4,223,501 and 5,596,855, which employ perforated metal plates with comparatively small openings, and U.S. Patent No. 4,967,528, which employs a metal wire requiring an external clip to fasten the wire to an external plate. However, all such forms have significant limitations. With most, the openings through the tie are sufficiently small so as to impede the free flow of concrete during pouring. With forms such as the '528 form, multiple parts are required, and the tie is limited to providing connection at the top and bottom of the form, and thus provides inadequate strength for many form heights.

There remains a need in the industry for an insulated concrete form with superior strength that provides minimal obstruction to concrete flow when pouring. In general, having a form with ties on close centers, such as every six or twelve inches, is preferable. However, if the tie component can obstruct the flow of concrete when being poured, void or vacant spots can result which can seriously weaken the resulting wall. There similarly remains a need in the industry for a form which is reversible such that it may be assembled in a horizontal dimension in any orientation, with no "inside" or "outside" orientation to the form.

BRIEF SUMMARY OF THE INVENTION

The invention provides an insulating concrete form. In one preferred embodiment, the form includes two opposing panels of a polymeric material, with the ends of each panel including both a tongue and groove positioned such that the forms are reversible in a horizontal orientation. In another preferred embodiment, the opposing panels are joined together by a plurality of welded wire ties, with both horizontal and vertical members, the horizontal members having a right angle bend at

either end, with a metal attachment stud disposed within the right angle bend, the right angle bends and metal attachment studs being within the structures of the opposing panels.

The invention thus provides in one embodiment an insulating concrete form with first and second substantially opposing panels, each panel having a top surface, bottom surface, first end surface, second end surface, an exterior surface defining a wall and an interior surface for receiving concrete. The opposing panels are interconnected by at least two ties, each tie having a plurality of horizontal wires and a plurality of vertical wires, arrayed such that each horizontal wire in a tie touches and is fixed to each vertical wire in the tie.

The tie further includes at least three parallel horizontal wires arranged in a single plane, the wires spaced distances apart such that the total distance from the bottom-most horizontal wire to the top-most horizontal wire is less than the height of the two opposing panels, with each wire being of a length greater than the distance between the exterior surfaces of the two opposing panels, and with an equidistant right angle on each end of each horizontal wire, positioned such that each right angle bend is disposed between the exterior surface and the interior surface of a panel. There are also provided at least three parallel vertical wires arranged in a single plane, the wires spaced apart and arranged so as to be disposed within a distance less than the distance between the right angle bends on each end of the horizontal wires, with each wire being of a length at least equal to the total distance from the bottom-most horizontal wire to the top-most horizontal wire. The horizontal wires and vertical wires are disposed such that each horizontal wire touches and forms a right angle intersection with all vertical wires, and each vertical wire touches and forms a right angle intersection with all horizontal wires, with the wires being fixed one to the other at each intersection. A metal sheet is disposed within the interior of right angle on each end of the horizontal wires, with at least a portion of the metal sheet being substantially parallel to the exterior surface of the panel wherein such right angle is disposed. Each metal sheet is in contact with the each horizontal wire and fixed thereto. In a preferred embodiment, the wires are fixed at each intersection by means that includes a weld, and further the metal sheet is fixed to each horizontal wire by means that include at least one weld.

In the tie, each vertical wire can include a semicircular bend at the intersection with each horizontal wire, the circle defined by the semicircular bend having a radius approximately equal to the diameter of the horizontal wire. In this way the horizontal wires and vertical wires are

substantially co-planar within the plane defined between the right angles on each end of the horizontal wires.

In one embodiment, the horizontal wires are spaced distances apart such that the total distance from the bottom-most horizontal wire to the top-most horizontal wire is between about 75% and about 95% of the height of the two opposing panels. The vertical wires are of a length between about 100% and about 110% of the total distance from the bottom-most horizontal wire to the top-most horizontal wire.

In a preferred embodiment, a portion of the metal sheet, and preferably the larger part of the metal sheet, is substantially perpendicular to the exterior surface of the panel wherein such right angle is disposed. In this way the metal sheet forms an attachment stud for attaching wall coverings and other structures by means of screws.

In the form, the first end surface and second end surface of the first panel and second panel have both a tongue and groove, disposed such that on the first end surface of the first panel the tongue is proximal the exterior surface and the groove proximal the interior surface and on the second end surface of the first panel the groove is proximal the exterior surface and the tongue proximal the interior surface. On the first end surface of the second panel the groove is proximal the exterior surface and the tongue proximal the interior surface and on the second end surface of the second panel the tongue is proximal the exterior surface and the groove proximal the interior surface. The panels are disposed such that the first end surface of the first panel opposes the first end surface of the second panel and the second end surface of the first panel opposes the second end surface of the second panel. By use of this structure two or more forms may be horizontally positioned and interlocked to form a planar surface by means of a joint formed by both a tongue and a groove on each panel of one form interconnecting with a groove and a tongue on each panel of another form, the forms being reversibly connectable such that the first end surface of the first and second panels of one form may be joined with either the first end surface or the second end surface of the first and second panels of another form.

The top surface of both the first and second panel can include either a tongue or a groove, with the bottom surface of the first and second panel having the complementary tongue or groove. In this way two or more forms may be vertically stacked and interlocked to form a planar surface by

means of a joint formed by a single tongue on each panel of one form interconnecting with a single groove on each panel of another form.

A primary object of the present invention is to provide an ICF with a welded wire tie, the welded wire tie including at least three horizontal wire and three vertical wires, wherein each end of the horizontal wires are bent to form a right angle, with a steel strip disposed within the right angle, and forming an attachment stud for attaching wall coverings to the ICF.

Another object of the present invention is to provide an ICF which is reversible, such that either end of any form may be attached in a horizontal direction to either end of any other form.

Another object of the present invention is to provide an ICF which combines the advantages of a reversible form with a welded wire tie.

Another object of the present invention is to provide an ICF wherein each panel of the ICF includes both a tongue and a groove, thereby resulting in a more secure attachment between forms.

A primary advantage of the present invention is that the wire ties provide increased structural strength between the opposing panels of the ICF.

Another advantage of the present invention is that construction is simplified, in that there is no defined "inside" or "outside" on forms, and forms may be connected in a horizontal orientation such that either end of any ICF may be joined to either end of any other ICF.

Other objects, advantages and novel features, and further scope of applicability of the present invention will be set forth in part in the detailed description to follow, taken in conjunction with the accompanying drawings, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The accompanying drawings, which are incorporated into and form a part of the specification, illustrate one or more embodiments of the present invention and, together with the description, serve to explain the principles of the invention. The drawings are only for the purpose of illustrating one or more preferred embodiments of the invention and are not to be construed as limiting the invention. In the drawings:

FIG. 1 is an illustration of a waffle grid form of the invention;

FIG. 2 is an illustration of a partially cutaway waffle grid form of the invention, showing the form partially filled with concrete with the tie and attachment stud illustrated;

FIG. 3 is an illustration of a partially cutaway flat panel form of the invention; showing the form partially filed with concrete with the tie and attachment stud illustrated;

FIG. 4 is a top view of a waffle grid form of the invention, showing two opposing panels, with the interior cavity configured in a waffle structure, the two opposing panels joined by metal wire ties of the invention;

FIG. 4A is a detail view of the placement of the wire tie of the invention within the wall of a panel of the form of FIG. 4, illustrating placement of the attachment stud;

FIG. 5 is an end view of a waffle grid form of the invention, showing the end tongue and groove on each panel, with a groove disposed on the bottom of each panel and a tongue disposed on the top of each panel;

FIG. 5A is a detail view of the top tongue on a panel of the form of FIG. 5, showing a bevel on the tongue;

FIG. 6 is a top view of a right angle corner waffle grid form of the invention;

FIG. 7 is a top view of a forty-five degree angle corner waffle grid form of the invention;

FIG. 8 is a side view of a flat panel form of the invention;

FIG. 9 is a top view of a flat panel form of the invention, showing two opposing panels, with the interior cavity configured in a flat structure, the two opposing panels joined by metal wire ties of the invention;

FIG. 10 is a detail drawing of the end of a panel of a flat panel form of the invention;

FIG. 11 is a cross-section view of a flat panel form of the invention;

FIG. 12 is a top view of a forty-five degree angle corner flat panel form of the invention;

FIG. 13 is a top view of a right angle corner flat panel form of the invention;

FIG. 14 is a detail top view of the end of a panel of a flat panel form of the invention;

FIG. 15 is a front view of a metal wire tie of the invention, prior to introduction of right angle bends at either horizontal end of the tie;

FIG. 16 is a top view of a metal wire tie of the invention, prior to introduction of right angle bends at either horizontal end of the tie;

FIG. 17 is a top view of a metal wire tie of the invention, depicting the right angle bends at both horizontal ends of the tie;

FIG. 18 is a detail view of an interconnection of a horizontal and vertical wire of the metal wire tie, wherein the vertical wire has a semicircular bend at the intersection with the horizontal wire, the circle defined by the semicircular bend having a radius approximately equal to the diameter of the horizontal wire, such that the horizontal wire and vertical wire are substantially co-planar;

FIG. 19 is a top view of an alternative configuration of the metal wire tie of the invention, prior to introduction of right angle bends at either horizontal end of the tie; and

FIG. 20 is a detail top view of a right angle bend at one horizontal end of a metal wire tie.

DETAILED DESCRIPTION OF THE INVENTION

FIG.1 depicts waffle grid form **10** of the invention, made of opposing panels **50** and **70** joined together by a plurality of metal ties **150**. Panels **50** and **70** are preferably made of an insulating polymeric material, which is preferably a moldable polymeric material. In a preferred embodiment, panels **50** and **70** are made of an expanded polystyrene material, with a density of approximately 1.5 lbs. per cubic foot. Waffle grid form **10** may be provided in a variety of widths; in one embodiment, the form has an overall width of about 9.25 inches, with a maximum concrete core width of about 6 inches; in another embodiment, the form has an overall width of about 11 inches, with a maximum concrete core width of about 8 inches; and in yet another embodiment, the form has an overall width of about 14 inches, with a maximum concrete core width of about 10 inches. Waffle grid form **10** may be any convenient length suitable for use in construction; in one embodiment the form has a length of 48 inches. Similarly, the height may be selected such as to be suitable for use in construction; in one embodiment the form has a height of 16 inches. The external surface of panels **50** and **70** are substantially planar, with vertical grooves designating the position within the form of the attachment stud, also called a furring strip, forming a part of metal tie **150**.

FIG. 2 depicts partially cutaway waffle grid form **10**, which form is partially filled with concrete **2**, concrete **2** being a part of the completed wall, and not a part of form **10**. FIG. 2 further depicts ties **150**, **150'**, and **150"** disposed within form **10**. The ties **150**, **150'**, and **150"** are formed from a suitable gauge of steel wire, such as 11 gauge minimum thickness wire, with a steel attachment stud disposed within the right angle bend of horizontal wires of the ties. The steel attachment stud is

formed of a suitable thickness steel sheet, such as about 22 gauge steel. It may be seen that the steel attachment stud is disposed within the wall of panel **50**, such that the steel attachment stud is a determined distance from the exterior of panel **50**, such as about one-half inch. The ties **150, 150'**, and **150"**, including the wires and steel attachment stud, may be galvanized. The interior of panels **50, 70** are shaped such that the concrete, when introduced, forms a "waffle grid" pattern, comprising a series of concrete posts and beams, connected with solid concrete webs. For example, waffle grid form **10** with an overall width of about 14 inches provides 10 inch solid concrete posts, connected with 3 ½ inch solid concrete webs.

FIG. 3 depicts partially cutaway flat panel form **20** of the invention, made of opposing panels **100** and **120** joined together by a plurality of metal ties **152, 152'**, and **152"**, which form is partially filled with concrete **2**, concrete **2** being a part of the completed wall, and not a part of form **20**. Flat panel form **20** may be provided in a variety of widths; in one embodiment, the form has an overall width of about 11 inches, with a concrete core width of about 6 inches; in another embodiment, the form has an overall width of about 13 inches, with a concrete core width of about 8 inches. Flat panel form **20** may be any convenient length suitable for use in construction; in one embodiment the form has a length of 48 inches. Similarly, the height may be selected such as to be suitable for use in construction; in one embodiment form **20** has a height of 24 inches. In another embodiment, form **20** has a height of 12 inches.

In forms **10, 20** of FIGS. 1 to 3, metal ties **150** or **152, 152'**, and **152"** are spaced on a standard and conventional distance on center; in one preferred embodiment of form **20**, the metal ties are spaced every 6 inches on center. In a preferred embodiment of form **10**, the metal ties are spaced every 12 inches on center. As shown in FIG 4, the distance "a" is a set and equal distance, such that the center lines of attachment studs of metal ties **150, 150'**, and **150"** are at an equal distance. As shown in FIG. 4, metal tie **150** may be reversed with respect to other metal ties, such as **150'**, so that the attachment studs remain on center without the metal tie **150** interfering with the tongue and groove members of form **10**.

In FIG. 4, the cavity wall **54** depicts that portion of form **10** defining a concrete post, upon introduction of concrete, and cavity wall **52** depicts that portion of form **10** defining a concrete web, again upon introduction of concrete. Panel **50** includes, at one end, planar area **66**, which planar area abuts against a like area of another form when two or more forms are joined together in

horizontal orientation. Tongue **58** is adjacent to and of reciprocal shape with groove **60**, with adjacent thereto being second planar area **56**. The opposite end of panel **50** includes the same elements, but arranged such that groove **62** is opposite tongue **58**, both disposed on the exterior side of panel **50**, and tongue **64** is opposite groove **60**, both disposed on the interior side of panel **50**. Preferably grooves **60**, **62** are of somewhat greater depth than the height of tongues **58**, **64**, such that the tongues fit within the grooves without binding or bottoming. In one embodiment, the grooves **60**, **62** have a nominal depth of about .42 inches, while the tongues **58**, **64** have a nominal height of about .37 inches. The width of grooves **60**, **62** may be approximately equal to that of tongues **58**, **64**, thereby insuring a tight fit. Opposing panel **50** is panel **70**, containing the same elements as panel **50**. However, panel **70** is constructed such that groove **80** is the disposed on the exterior side of panel **70**, while tongue **78** is adjacent thereto but disposed on the interior side of panel **70**. Planar area **68** is provided on the exterior side of panel **70**, while second planar area **76** is provided on the interior side. The opposite end of panel **70** includes the same elements, but arranged such that groove **82** is opposite tongue **78**, both disposed on the interior side of panel **70**, and tongue **84** is opposite groove **80**, both disposed on the exterior side of panel **70**. It may thus be seen that on form **10** panels **50**, **70** are constructed such that at one end the outermost joining end element is a tongue and a groove, such as tongue **58** and groove **80**, while at the opposite end the outermost joining end element position is reversed. In this way, the forms are reversible; that is, given a plurality of forms **10**, such forms may be joined together in a horizontal dimension even though any single form is rotated 180°, and the forms still interconnect and join.

As shown in FIG. 4A, wire tie **150** includes horizontal wire **160** bent to form a right angle, and disposed therein metal attachment stud **180'**. The tie is positioned within the form such that the exterior surface of wire **160** is embedded within the polymeric substrate of panel **50** a suitable distance, such as about one-half inch, with the position of metal attachment stud **180'** within the form indicated on the exterior of panel **50** by means of grooves **98**, **98'**. In one preferred embodiment, the width of metal attachment stud **180'**, and thus the distance between grooves **98**, **98'**, is about 1½ inches.

FIG. 5 depicts an end view of form **10**, showing tongue **92** disposed on the top of panel **50**, with groove **96** disposed on the bottom thereof, and corresponding tongue **90** and groove **94** on panel **70**. Also shown is metal tie **150**; it may thus be seen that metal tie **150** is a substantial portion

of the height of panels **50, 70**; in one preferred embodiment, panels **50, 70** have a height of 16 inches, while tie **150** has a height of 13 inches. Tongues **58, 78** are shown, and have a radius curve on the top and bottom of each, to permit facile introduction into the grooves, such as grooves **60, 80**, which grooves run the height of the available distance of panels **50, 70**. Planar areas **66, 68** are co-planar one with the other, and are further optionally co-planar with second planar areas **56, 76**, which are also co-planar one with the other. FIG. 5A depicts a detail of the top of panel **50**, showing tongue **92** having a slight exterior curve on the top outer corner, thereby facilitating joining together two forms in a vertical orientation.

FIGS. 6 and 7 depict respectively right angle waffle grid form **12**, for a right angle corner in a wall made of forms **10**, and forty-five degree angle waffle grid form **14**, for a forty-five degree angle in a wall made of forms **10**. Panel **30** includes a right angle turn, while the interior is a "stub" panel **32** which does not include a turn. Both panels **34, 36** include forty-five degree turns; as shown in FIG. 7, the tongues and grooves are arranged as in FIG. 4.

FIG. 8 depicts a side view of flat wall form **20**, showing the exterior of panel **100**. Grooves **98, 98'** mark, on the exterior of panel **100**, the position within panel **100** of metal attachment stud **180** forming a part of tie **150**. The distances "a" are all equal in FIGS. 8 and 9, with the distances "b" plus "b" equal to "a", such that when two or more forms are positioned in a horizontal direction, the distances between the centerlines of any two adjacent areas defined by grooves **98, 98'** are each the same, including the distance between centerlines on two adjacent forms. As shown in FIG. 9, form **20** includes panels **100** and **120**. Tongue **108** is disposed on the exterior side of panel **100**, with groove **110** on the interior side; on the opposite end, opposing tongue **108** is groove **112**, and opposing groove **110** is tongue **114**. Planar area **116** is opposite corresponding planar area **140**, and second planar area **106** is disposed opposite corresponding second planar area **144**. Opposing panel **120** is complementary, such that groove **130** is on the exterior side of such panel, with tongue **128** on the interior, and opposing groove **130** is tongue **134**, and opposing tongue **128** is groove **132**. Similarly, planar area **118** is opposite corresponding planar area **142**, and second planar area **126** is disposed opposite corresponding second planar area **146**. Planar areas **116, 118** are co-planar one with the other, and are further optionally co-planar with second planar areas **106, 126**, which are also co-planar one with the other. Panels **100, 120** are joined together by means of metal ties **152, 152'**, and **152"**; as shown, tie **152"** is reversed in orientation with respect to ties **152, 152'**.

FIG. 10 depicts a detail of the end of panel **120**, showing tongue **136** disposed on the top thereof, with groove **138** on the bottom. Also shown is tongue **128**, with the top and bottom thereof having a radius curve, to thereby engage more easily with a corresponding groove. Groove **130** adjoins tongue **128**. The top view shown in FIG. 14 further depicts the radius curve on the top of tongue **108**, and the relationship of the top of tongue **136** with respect to end groove **110**. FIG. 11 is a cross-section of form **20**; as shown therein tie **152** extends for very nearly the height of panels **100**, **120**. In one embodiment, panels **100**, **120** are approximately 24 inches in height, while tie **152** is 21 inches in height.

FIG. 12 depicts forty-five degree angle form **24**, for a forty-five degree angle in a wall made of forms **20**. FIG. 13 depicts right angle form **22**, for a right angle corner in a wall made of forms **20**. Panels **40**, **42** each include a right angle turn. Similarly, both panels **44**, **46** include forty-five degree turns; as shown in FIGS. 12 and 13, the tongues and grooves are arranged as in form **20** of FIG. 9.

In form **22** of FIG. 13 there are depicted corner attachment studs **48**, **48'**, providing a metal strip on each plane adjacent the intersection as shown. The corner attachment studs **48**, **48'** thus provide an attachment stud of a dimension substantially the same as that of metal strip **180**, and arranged in the same orientation. The corner attachment studs **48**, **48'** can further include a portion that extends into the cavity, as shown, for securing the corner attachment studs **48**, **48'** to the concrete. The portion extending into the cavity may be made of expanded metal, with the portion corresponding to metal strip **180** consisting of a solid metal sheet. While corner attachment studs **48**, **48'** are shown only in connection with form **22**, it is to be understood that similar corner attachment studs may be employed in any corner form, including forms **12**, **14** or **14**.

FIG. 15 depicts tie **152**, made up of a plurality of horizontal metal wires **160**, **160'**, **160"**, **160"'**, **160""**, **160"""**, and vertical wires **162**, **162'**, **162"**. The horizontal and vertical wires are at right angles, and each wire is affixed to each other wire at the intersection point thereof. Such affixing or joining may be by any means, including mechanical fasteners, adhesives or the like; in a preferred embodiment the wires are welded one to the other. The wires are of a suitable diameter to provide the requisite structural strength and integrity; in a preferred embodiment the diameter of the wires range from about 0.10 inches to about 0.15 inches, and most preferably about 0.12 inches. Metal attachment studs **180**, **180'** are affixed or joined to horizontal wires **160**, **160'**, **160"**, **160"'**, **160""**, **160"""** by any means, including mechanical fasteners, adhesives or the like; in a preferred

embodiment the studs are welded to the horizontal wires; preferably welded to each horizontal wire in two spots. The tie **152** may be galvanized or otherwise coated to provide protection against rust or other corrosion prior to use of the form. Each of horizontal metal wires **160, 160', 160", 160"', 160"", 160""'** are co-planar one with the other, and similarly each of vertical wires **162, 162', 162"** are co-planar one with the other. As is shown in FIG. 18, it is possible and contemplated that vertical wire **162'** (and all other vertical wires) has a semicircular bend at the intersection with horizontal wire **160'** (and all other horizontal wires) the circle defined by the semicircular bend having a radius approximately equal to the diameter of the horizontal wire, such that horizontal wire **160'** and vertical wire **162'** (and all other vertical and horizontal wires) are substantially co-planar. The semicircular bend may be a crimp, and may be formed by pressing means, including pressing and forming the bend or crimp in the vertical wire using the horizontal wire. Alternatively, the horizontal wires and vertical wires may constitute two separate planes, with each horizontal wire contacting each vertical wire, and vice versa. Alternative configuration metal tie **150** is shown in FIG. 19, depicting a plurality of horizontal metal wires **160, 160', 160", 160"', 160""**, and vertical wires **162, 162', 162", 162"'**, and metal attachment studs **180, 180'**. A top view of tie **150** is shown in FIG. 16; it may be seen that in that embodiment metal attachment studs **180, 180'** extend slightly beyond the end of horizontal wire **160**. The length of tie **150**, prior to introduction of the right angle bends, is greater than the width of corresponding form **10**; as shown in FIG. 17 the ends of wire **160**, and optionally including a portion of metal attachment studs **180, 180'**, are bend in a right angle, such that tie **150** with right angle bends is wholly disposed within a distance slightly less than the width of form **10**, as shown in FIG. 4. Preferably the tie **150** is of a length such that metal attachment studs **180, 180'** lie a fixed distance below the external surface of panels **50, 70**, such as about one-half inch below the surface.

Metal attachment studs **180, 180'** are preferably metal strips of a steel metal of suitable gauge for use with standard dry-wall screws, self-tapping screws or sheet metal screws. In one embodiment, a 22 gauge strip is employed. Studs **180, 180'** may similarly be galvanized, and preferably are galvanized together with the vertical and horizontal wires. It may be seen, as shown in FIGS. 17 and 20, that the metal attachment stud **180'** is disposed within the interior of the horizontal wires **160, 160', 160", 160"', 160""**, and thus the horizontal wires serve to secure and hold in place metal attachment stud **180'** during use.

The invention thus provides insulating concrete forms consisting of two panels of expanded polystyrene or other insulating polymeric material tied together with a form tie of metal, preferably steel, which provides an attachment surface which runs parallel to the surface of each panel either directly on the surface of the form, or is submerged within the structure of the panel, such as about one-half inch from the exterior surface of the panel. The foam panels are preferably molded around the ties, so that the ties become an integral part of a molded form. Alternatively the ties are separate pieces used to assemble two independently formed or cut panels of foam to make a form, such as assembly in the field as walls are being constructed.

Three key functions of the form ties are provided: to maintain the integrity of the form during the placement of concrete by preventing the foam panels from deforming or separating, to provide ample space for concrete to flow through and around the tie to facilitate the formation of a solid concrete wall, and to provide a secure surface for the mechanical attachment of interior and exterior wall coverings. Each form tie consists of welded wire, such as welded galvanized steel wire, of any specified diameter, spaced at regulated intervals, depending on the form size and thickness. The width and height of the steel grid is dependent on the height and thickness of the expanded polystyrene (EPS) form.

In one embodiment on each vertical edge of the grid is a galvanized steel strip, approximately 1¾ inches to 2 inches in width, which is bent in the vertical plane at a right angle (a 90° angle) to align the surface of the strip in a parallel plane to the exterior surface of the EPS form. This galvanized steep strip forms an attachment stud, providing a secure surface for the mechanical attachment of interior and exterior wall coverings. The strip is bent such that at least part of the strip, and preferably a majority of the strips remain in the same plane as the wire grid. The bend in the steel creates a much higher moment of inertia and section modulus, which adds significant strength to the strip itself, and to the entire tie assembly. The horizontal wires of the tie grid extend to the outside of the bend, which restrains the steel strip in case of separation of the assembly and reinforces the "pull-out" strength of the strip when wall coverings are mechanically attached.

In another embodiment, the strip utilized as an attachment stud may be made from alternative materials, including an expanded or perforated metal strip. Similarly, the width of the strip may vary, depending on the specific application, realizing that sufficient width should be provided to permit the strip to function as an attachment stud.

The use of welded wire maximizes the flow of concrete within the form by minimizing the restrictive surface area of the tie, providing a distinct working advantage during the placement of concrete. The strength of the welded wire and bent-strip design is sufficient to hold the form together under the extreme pressures of concrete placement, while introducing almost no tie material into the form cavity which might restrict the flow of concrete.

The welded wire ties may be constructed such that the horizontal and vertical wires are essentially co-planer, with a circular radius bend in one or both wires at the point of intersection. Thus the wires of the wire ties are essentially co-planer and the thickness of the wire, except at intersection points of horizontal and vertical wires, where the wire portion has a thickness of two wires.

The welded wire ties are conventionally welded at each intersection point of the horizontal and vertical wires. The steel strip, whether solid, galvanized, perforated, expanded or otherwise fabricated, can conventionally be continuously welded to the horizontal wire members at all points of contact therewith. In the embodiment wherein the strip itself is bent in the vertical plane at a right angle to align a surface of the strip in a parallel plane to the surface of the EPS form, it is possible and contemplated that the strip will be welded to the horizontal wire members on both planes.

While wire has been used in other concrete forming applications, the invention disclosed herein provides a unique combination of a welded wire grid with an attached steel strip, bent to both strengthen the assembly and provide for a secure, fire-resistant attachment surface for mechanically attaching wall finishes.

It is further to be understood that while this invention is described in terms of expanded polystyrene forms, any plastic or other material that can be suitably molded and provide desired insulating properties may be employed. The use of related polymeric materials for insulation and similar applications is known in the art.

The welded steel form tie of this invention offers more strength, improved concrete flow, and a larger, more secure attachment stud than other ties known in the art. In one embodiment the welded steel form tie is made of heavy-gauge galvanized steel wire welded together in at least 40 locations, including to the attachment stud, to ensure the structural integrity of each form. The ties in the 16 inch high waffle forms are in one embodiment a full 13 inches tall, and may in another embodiment be 21 inches tall in flat panel forms with a 24 inch height. Generous spacing of the

steel wires within the welded steel tie virtually eliminates any obstruction to the flow of concrete in the insulating concrete forms of this invention, significantly improving the consolidation of the concrete and the speed of construction. This design also minimizes the vibration of the forms during concrete placement and stabilizes the entire wall. The insulating concrete form of this invention has a recessed attachment stud, forming a part of the welded steel form tie, which is 1-1/2" wide, and is clearly marked on both sides for the full height of the form. This recessed feature simplifies the application of synthetic stuccos and other bonded surface coatings. The ties are placed so that the attachment studs remain on center, such as on 6 or 12 inches centers, regardless of the direction in which the form is installed. The insulating concrete forms of this invention are thus reversible end-to-end. The ties are spaced to allow end-to-end reversibility, so that insulating concrete forms of this invention can be installed in any direction, while maintaining the structural integrity of the concrete posts and the alignment of the attachment studs. This feature also allows for the efficient pre-panelization or assembly of wall sections that can significantly speed the process of installation. The insulating concrete form further uses a tongue and groove design to permit the form to be wet-set, thereby allowing the form to be easily and speedily erected.

The combination of a tongue and groove on each panel of the insulating concrete form of this invention permits the forms to be reversible end-to-end, while providing continuous insulation. Forms which are butt fit without an interlocking means are susceptible to heat loss through cracks. By use of both a tongue and a groove on each panel, the insulation is thus continuous with no heat loss.

Although the invention has been described in detail with particular reference to these preferred embodiments, other embodiments can achieve the same results. Variations and modifications of the present invention will be obvious to those skilled in the art and it is intended to cover in the appended claims all such modifications and equivalents. The entire disclosures of all references, applications, patents, and publications cited above are hereby incorporated by reference.